

REMARKS

Applicant provisionally elected with traverse to pursue Claims 1-11 in a telephone conversation with the Examiner during a telephone conversation on March 14, 2003. Applicant affirms that election with traverse, and notes that Claims 12-20 stand withdrawn from further consideration in this application.

Claims 1, 3, and 6-9 stand rejected under 35 U.S.C. § 103(a), as being unpatentable over Andersen, U.S. Patent No. 2,938,807 or Fitchmun, U.S. Patent No. 3,947,550, in view of Kennedy, U.S. Patent No. 5,024,795. The Examiner has rejected Claims 2, 4-5, and 9-11 under 35 U.S.C 103(a), citing Andersen or Fitchmun in view of Kennedy and in further view of Singh, U.S. Patent No. 5,945,166. Claims 2-4 and 9 have been cancelled. Claims 1, 6, 8, and 10 have been amended.

The present invention is a reaction-forming method for producing monolithic, near-net-shape refractory metal carbides. The method involves first fabricating an initial glassy carbon preform by casting an organic, resin-based mixture into a mold and subsequently heat treating the mixture in two steps.

The heat treatment consists of a low-temperature step carried out at a suitable temperature to cure the resin and a high-temperature step carried out at a suitable temperature to pyrolyze the cured resin mixture leaving only a porous carbon preform. The amounts of reactants in the initial mixture can be varied permitting control over the density and microstructure of the carbon preform, which subsequently influences the microstructure and properties of the final refractory metal carbide material produced.

The glassy carbon preform is placed on a bed of refractory metal or refractory metal-silicon alloy pieces and heated above the melting point of the metal or alloy. The molten metal wicks inside the porous carbon preform and reacts, forming a refractory metal carbide or a refractory metal carbide plus a refractory metal silicide, depending on the composition of the infiltrating metal.

The refractory metal carbides of the present invention can be closely engineered by varying the constituents of the organic, resin-based mixture. The mixture may be cast into a wide variety of complex shapes, which are reflected in the shape of the refractory metal carbide produced by the present method.

Rejections under 103(a)

The Examiner rejected the claims as being obvious over Andersen, U.S. Patent No. 2,938,807 or Fitchmun, U.S. Patent No. 3,947,550, in view of Kennedy, U.S. Patent No. 5,024,795. Applicant has cancelled Claims 3 and 9 and amended Claims 1, 6, and 8 to address the Examiner's rejection of Claims 1, 3, and 6-9 under 35 U.S.C. 103(a). Applicant respectfully argues that the present invention is significantly distinguishable over the Andersen or Fitchmun in view of Kennedy, particularly when viewed in light of the amended claims. To justify a rejection under Section 103(a), there must be some suggestion or motivation, either in the references or in the knowledge generally available to one of ordinary skill in the art, to modify the reference or to combine reference teachings. Applicant respectfully argues that one of ordinary skill in the art of reaction-forming methods for producing near-net shape refractory metal carbides would not be motivated to modify the method described in Andersen or Fitchmun, nor to combine either of those methods with the method described in Kennedy.

Andersen describes a method for making silicon carbide bodies. Andersen teaches silicon carbides only. By contrast, the present invention teaches making other refractory metal carbides. As Applicant stated on page 2 of the specification, "reaction forming . . . is limited to a single material, such as silicon carbide . . . . Many other refractory metal carbides are of interest for their high-temperature properties . . . ." A primary motivation of this invention was to develop refractory metal carbides other than silicon carbide for use in such environments. Therefore, one skilled in the art of refractory metal carbides for high-temperature environments would not have been motivated to modify the invention of Andersen.

Another difference between Andersen and the present invention is that Andersen uses pressure (col. 4, line 56) in its process, therefore, pour molding will not work. The fact that Andersen requires pressure teaches away from the present invention. The present invention does not require pressure, and the resin-containing mixture can be pour-molded, which is important for the creation of complex, near-net shapes.

A third difference between Andersen and the present invention is that all examples in Andersen and claim 8 (col. 8, line 66) state that silicon infiltration temperature must be at least 1850 ° C. The present method can be performed at temperatures as low as about 1300 ° C. To better differentiate between the present invention and Andersen, Claims 6, 8, and 10 have been amended to reflect a lower temperature range of between about 1300 ° C and about 1700 ° C.

Fitchmun teaches a method of making silicon carbide articles of less than full density. The process described in Fitchmun uses silicon particles in the starting mixture (col. 6, lines 49-50). The present invention does not use silicon particles in the starting mixture. Furthermore, the Fitchmun process does not infiltrate with silicon in its final stage of fabrication. The present

invention uses infiltration in the final step. Finally, Fitchmun requires the mixture to be heated before molding (col. 6, lines 54-58). The present invention is not heated before molding.

Kennedy provides a method for producing ceramic composites. The method of Kennedy does not produce refractory metal carbides, but metal oxides. The carbon or graphite used in the present invention would not work in the Kennedy process because the carbon would likely oxidize to gaseous carbon dioxide or carbon monoxide. Additionally, the preforms discussed in Kennedy (col. 10, line 15, and col. 11, lines 15-18) are not carbon, and do not result in refractory metal carbides as specifically claimed in the present invention. The preforms of Kennedy (cols. 10-11) are not derived from an organic, resin-based liquid mixture. Furthermore, the slip casting technique of Kennedy (col. 14, line 49) is different from pour molding, which is the technique of the present invention. Slip casting will not work for the present invention because the present invention does not use water in the process. These differences in the Kennedy process teach away from the present invention. Furthermore, it is not obvious to include high-temperature fibers in the preform to provide reinforcement because the change in the mixture viscosity due to the fibers can greatly affect the fabrication process.

The Examiner has rejected Claims 2, 4-5, and 9-11 under 35 U.S.C 103(a), citing Andersen or Fitchmun in view of Kennedy and in further view of Singh, U.S. Patent No. 5,945,166. Applicant has cancelled Claims 2 and 4 and has amended Claim 10. Applicant respectfully argues that the present invention is significantly distinguishable over the Andersen or Fitchmun in view of Kennedy and in further view of Singh, particularly in light of amended Claim 10. To justify a rejection under Section 103(a), there must be some suggestion or motivation, either in the references or in the knowledge generally available to one of ordinary

skill in the art, to modify the reference or to combine reference teachings. Applicant respectfully argues that one of ordinary skill in the art of reaction-forming methods for producing near-net shape refractory metal carbides would not be motivated to modify the method described in Andersen or Fitchmun, nor to combine either of those methods with the methods described in Kennedy and Singh.

Andersen (Table 3) does not use glycols, a catalyst, or refractory metals other than silicon. Furthermore, Fitchmun (col. 2 line 59) does not use glycols or a catalyst, as is needed for our process as stated in Claim 1, as amended. To elucidate those differences, Claim 4 has been cancelled. Furthermore, the method of Andersen does not produce a refractory metal silicide. To clarify that difference, Claim 2 has been cancelled and Claim 1 has been amended.

The method of Singh produces fiber-reinforced silicon carbide composites with a graded composition (Abstract). The Singh product is a graded composite, while the product of the present invention is not. Furthermore, the material in Singh must contain both silicon and other refractory materials. By contrast, the present invention does not require silicon. Additionally, the Singh process begins with a fiber preform (col. 3, lines 19-20), whereas our process places fibers the resin-containing mixture. To further define this difference, Claim 9 has been cancelled and Claim 1 has been amended.

As discussed above, Applicant respectfully argues that persons skilled in the art of methods for making refractory metal carbides would not be motivated to modify the references, absent hindsight, either singly or in any combination, to make the subject invention. Applicant respectfully submits that no suggestion or motivation to modify the references or to combine reference teachings existed in those references or in the knowledge generally available to one of

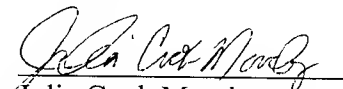
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ordinary skill in the art at the time the invention was made, and indeed, some aspects of Andersen and Kennedy actually teach away from the present invention. Only if the art were consulted despite lack of suggestion to do so, cited parts extracted from the whole inventions, and hindsight were employed, would there be any way that the cited references could be combined to render the present invention obvious. Furthermore, Applicant respectfully argues that the cited references, either singly or combined, do not teach or suggest all of the claim limitations, particularly in light of the amended claims discussed herein. Therefore, Applicant respectfully argues that the subject invention is patentable over the cited references.

Conclusion

For the foregoing reasons, Applicant respectfully requests that the Examiner allow Claims 5, 7, and 11 and Claims 1, 6, 8, and 10, as amended.

Respectfully submitted,

  
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202-586-3815

Attachment

Dated: September 16, 2003

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COMPLETE LISTING OF CLAIMS, INCORPORATING AMENDMENTS

IN RESPONSE TO OFFICE ACTION DATED March 18, 2003

FOR SERIAL NO. 09/994,823

1. (Currently Amended) A method for producing a refractory metal carbide by a reaction-forming method comprising the steps of:

(a) casting into a mold an organic, resin-based liquid mixture ~~into a mold~~ comprising one or more organic-based resins, one or more glycols, a curing catalyst, one or more refractory  
5 metal carbides, and a plurality of high-temperature fibers;

(b) heating the organic, resin-based liquid mixture to suitable temperature and for a suitable period of time to cure the resin;

(c) heating the cured organic, resin-based mixture to a suitable temperature, for a suitable period of time, to pyrolyze the cured resin mixture to produce a pyrolyzed preform; and

10 (d) placing the pyrolyzed preform on a bed of refractory metal silicide at a temperature above the melting point of the metal such that the molten metal wicks inside the porous carbon preform and reacts, forming a refractory metal carbide.

2-4. (Cancel)

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5. (Original) The method of claim 1, wherein the organic, resin-based liquid mixture comprises a furfuryl alcohol resin, diethylene glycol, triethylene glycol, p-toluene sulfonic acid, and one or more refractory metal carbides, in powder form, selected from the group consisting of graphite, silicon carbide, zirconium carbide, titanium carbide, hafnium carbide, vanadium carbide, molybdenum carbide, niobium carbide, tantalum carbide, chromium carbide, or tungsten carbide.

6. (Currently Amended) The method of claim 1, wherein the curing step (b) is carried out at a temperature of 50°C to 200°C, the pyrolysis step (c) is carried out at a temperature of 500°C to 1,200°C, and the infiltration step (d) is carried out at a temperature of 1,300°C to ~~4,000°C~~ 1,700°C.

7. (Original) The method of claim 5, wherein the density and chemical composition of the refractory metal carbide is controlled by altering the composition of the organic, resin-based liquid mixture.

8. (Currently Amended) The method of claim 1 wherein the processing temperature required for the infiltration step (d) is controlled by altering the composition of refractory metal used by the addition of silicon to the refractory metal composition and the infiltration step (d) is carried out at 1,300°C to ~~2,500°C~~ 1,700°C.

9. (Cancel)



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10. (Currently Amended) A method for producing a refractory metal carbide by a reaction-forming method comprising the steps of:

(a) casting an organic, resin-based liquid mixture comprising one or more organic-based resins, one or more glycols, a curing catalyst, and one or more refractory metal carbides  
5 into a mold;

(b) heating the organic, resin-based liquid mixture to 50°C to 200°C for a suitable period of time to cure the resin;

(c) heating the cured organic, resin-based mixture to 500°C to 1,200°C for a suitable period of time to pyrolyze the cured resin mixture to produce a pyrolyzed preform; and

10 (d) placing the pyrolyzed preform on a bed of refractory metal at a temperature of 1,300°C to ~~4,000°C~~ 1,700°C, wherein the temperature is above the melting point of the metal, such that the molten metal wicks inside the porous carbon preform and reacts, forming a refractory metal carbide.

11. (Original) The method of claim 10, wherein the resin comprises a furfuryl alcohol resin, the glycol comprises one or more glycols selected from the group consisting of diethylene glycol and triethylene glycol, the curing catalyst is p-toluene sulfonic, the refractory metal carbides are selected from the group consisting of graphite, silicon carbide, zirconium carbide,  
5 titanium carbide, hafnium carbide, vanadium carbide, molybdenum carbide, niobium carbide, tantalum carbide, chromium carbide, or tungsten carbide, and the refractory metal in step (d) comprises a refractory metal silicide.

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12. (Withdrawn) A refractory metal carbide prepared by a reaction-forming method comprising the steps of:

(a) casting an organic, resin-based liquid mixture comprising one or more organic-based resins, one or more glycols, a curing catalyst, and one or more refractory metal carbides  
5 into a mold;

(b) heating the organic, resin-based liquid mixture to 50°C to 200°C for a suitable period of time to cure the resin;

(c) heating the cured organic, resin-based mixture to 500°C to 1,200°C for a suitable period of time to pyrolyze the cured resin mixture to produce a pyrolyzed preform; and

10 (d) placing the pyrolyzed preform on a bed of refractory metal at a temperature of 1,300°C to 4,000°C, wherein the temperature is above the melting point of the metal, such that the molten metal wicks inside the porous carbon preform and reacts, forming a refractory metal carbide.

13. (Withdrawn) The refractory metal carbide of claim 12, wherein the refractory metal in step (d) comprises a refractory metal silicide.

14. (Withdrawn) The refractory metal carbide of claim 12, wherein the refractory metal carbide has the same geometry as the mold in step (a).

15. (Withdrawn) The refractory metal carbide of claim 14, wherein the mold geometry is a complex shape.

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16. (Withdrawn) The refractory metal carbide of claim 12, wherein the resin comprises a furfuryl alcohol resin.

17. (Withdrawn) The refractory metal carbide of claim 12, wherein the glycols comprise one or more selected from the group consisting of diethylene glycol and triethylene glycol.

18. (Withdrawn) The refractory metal carbide of claim 12, wherein the curing catalyst is p-toluene sulfonic.

19. (Withdrawn) The refractory metal carbide method of claim 12, wherein the refractory metal carbides are selected from the group consisting of graphite, silicon carbide, zirconium carbide, titanium carbide, hafnium carbide, vanadium carbide, molybdenum carbide, niobium carbide, tantalum carbide, chromium carbide, or tungsten carbide.

20. (Withdrawn) The refractory metal carbide of claim 12, wherein the refractory metal carbides are in powder form.